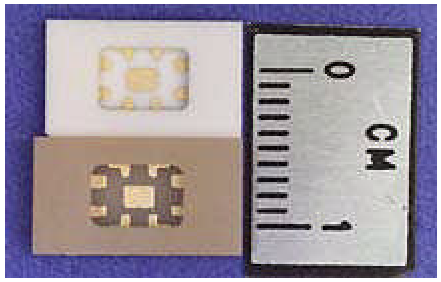
Packaging Technology Developed for High-Temperature Silicon Carbide Microsystems

High-temperature electronics and sensors are necessary for harsh-environment space and aeronautical applications, such as sensors and electronics for space missions to the inner solar system, sensors for in situ combustion and emission monitoring, and electronics for combustion control for aeronautical and automotive engines. However, these devices cannot be used until they can be packaged in appropriate forms for specific applications. Suitable packaging technology for operation temperatures up to 500 °C and beyond is not commercially available. Thus, the development of a systematic high-temperature packaging technology for SiC-based microsystems is essential for both in situ testing and commercializing high-temperature SiC sensors and electronics.

In response to these needs, researchers at Glenn innovatively designed, fabricated, and assembled a new prototype electronic package for high-temperature electronic microsystems using ceramic substrates (aluminum nitride and aluminum oxide) and gold (Au) thick-film metallization (see the figure). Packaging components include a ceramic packaging frame, thick-film metallization-based interconnection system, and a low-electrical-resistance SiC die-attachment scheme. Both the materials and fabrication process of the basic packaging components have been tested with an in-house-fabricated SiC semiconductor test chip in an oxidizing environment at temperatures from room temperature to 500 °C for more than 1000 hr. These test results set lifetime records for both high-temperature electronic packaging and high-temperature electronic device testing.

As required, the thick-film-based interconnection system demonstrated low (2.5 times of the room-temperature resistance of the Au conductor) and stable (decreased 3 percent in 1500 hr of continuous testing) electrical resistance at 500 °C in an oxidizing environment. Also as required, the electrical isolation impedance between printed wires that were not electrically joined by a wire bond remained high (>0.4 GΩ) at 500 °C in air. The attached SiC diode demonstrated low (< 3.8 Ω/mm^2) and relatively consistent dynamic resistance from room temperature to 500 °C. These results indicate that the prototype package and the compatible die-attach scheme meet the initial design standards for high-temperature, low-power, and long-term operation. This technology will be further developed and evaluated, especially with more mechanical tests of each packaging element for operation at higher temperatures and longer lifetimes.



Prototype high-temperature electronic package composed of ceramic substrates and Au thick-film metalization being developed for SiC microsystems with sensors and electronic devices.

Find out more about this research at http://www.grc.nasa.gov/WWW/sensors/.

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